

TECHNICAL OVERVIEW

# ESIG3000

**High Value  
High Performance  
Image Generation**

---

EVANS & SUTHERLAND

---

# ESIG-3000

## High Value, High Performance, Image Generation

The ESIG-3000 system is one of a new generation of high performance Image Generators from Evans & Sutherland. By combining their long experience in image generation technology with advanced development and state-of-the-art components, Evans & Sutherland has created a compact, flexible system that offers high performance at substantially lower cost. All this while remaining compatible with the current E&S family of databases.

With leading-edge technology, high baseline performance and modular architecture, the system can be configured to meet a wide variety of training applications including fixed-wing and helicopter pilot training, space operations simulation and vehicle engineering.

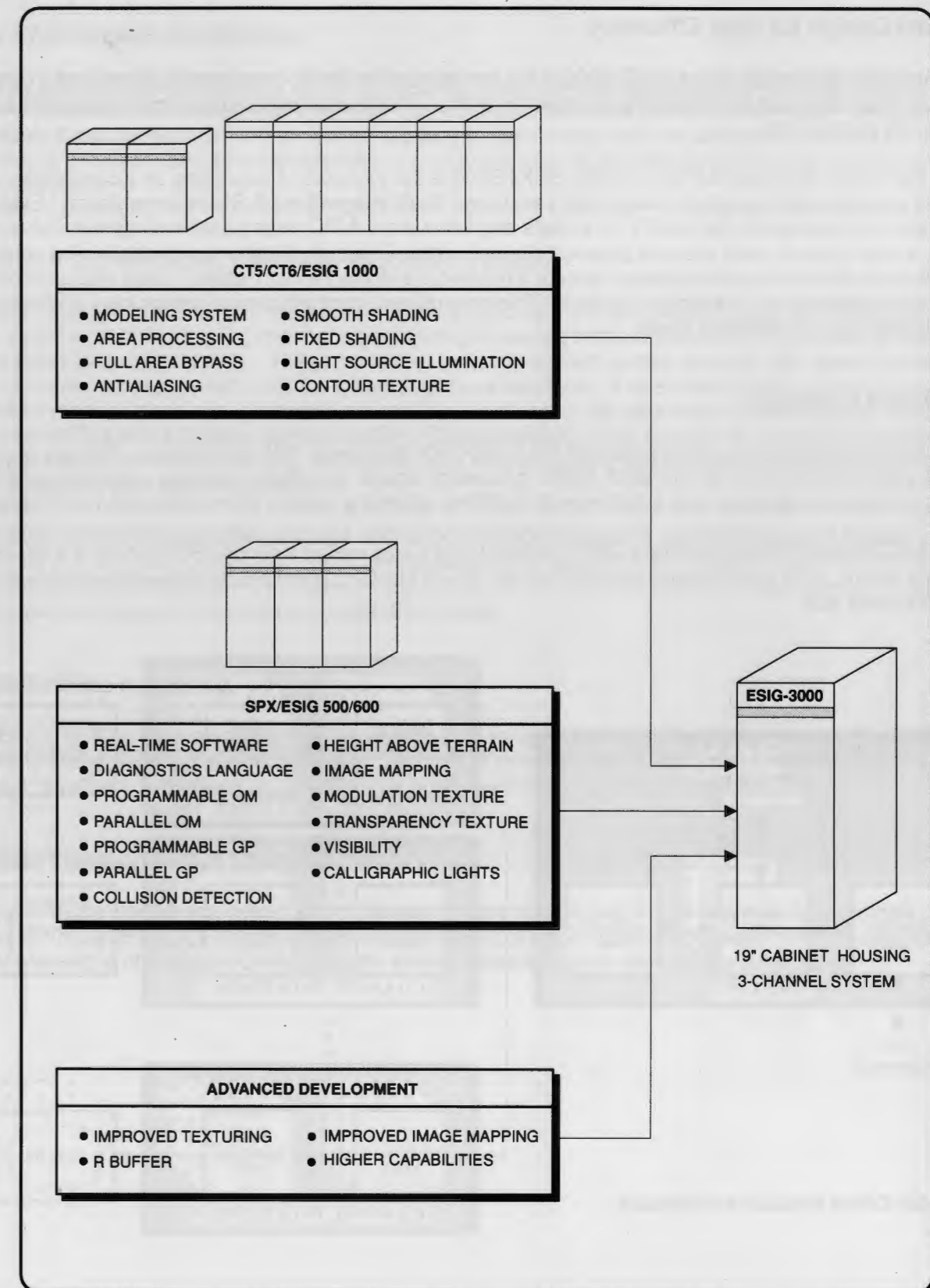
## Strong Family Heritage and Advanced Development

The ESIG-3000 is the result of an evolutionary process that has combined new capabilities with the best features from the broad E&S product line of image generators. Drawing on the proven architecture of the CT family of high performance systems including the CT5, CT6 and the ESIG-1000, the ESIG-3000 retains the distinctive, high image quality derived from area based image rendering, powerful database management and robust texture.

The ESIG-3000 builds on important features of the highly successful SPX family of low cost image generators, including the ESIG-500 and ESIG-600. These include high system reliability and extensive on-board diagnostics, programmable and parallel arithmetic processor units and configurable real-time software.

The proven foundation of solid architecture and algorithms are combined with a powerful range buffer, a highly integrated non-linear image mapping capability and full-color photo texturing. State-of-the-art implementation using Application Specific Integrated Circuits (ASIC) results in a small system that is highly reliable. By incorporating these advanced developments and a greatly increased performance, the ESIG-3000 provides a price/performance value not achievable in current systems.

## Development Evolution of ESIG-3000



## High Modularity and Configuration Flexibility

### Compact Design for High Efficiency

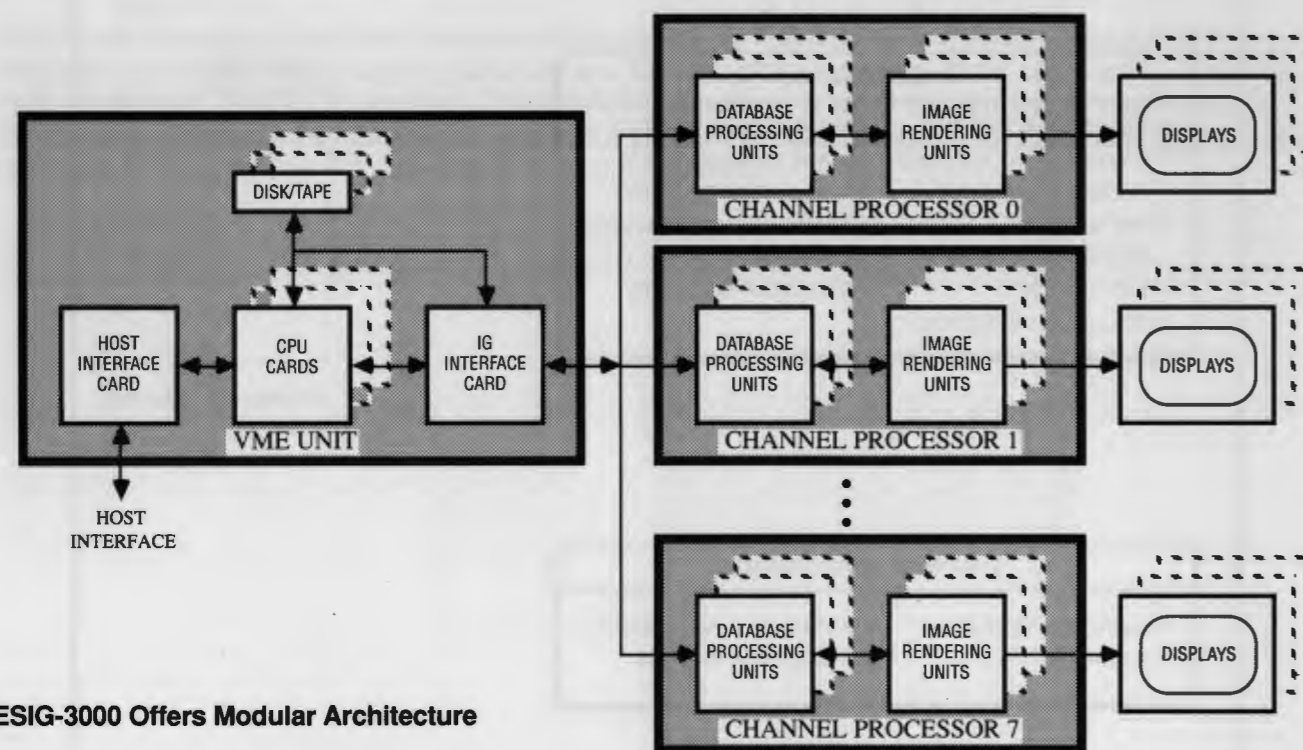
Fundamental to the design of the ESIG-3000 is the use of new electronic components, permitting a compact system configuration with high reliability and maintainability. This translates into lower acquisition costs, as well as lower life cycle costs.

One of the major objectives achieved in the ESIG-3000 is the increase of capacities and capabilities, while reducing size and cost through an almost total Very Large Scale Integration (VLSI) implementation. Extensive use of both commercial off-the-shelf VLSI circuits and full-custom ASIC chips allows reduction in the number of unique card types in each channel processor to only eight. The overall system package is also small and clean. A typical three-channel processor system is housed in a single 19-inch cabinet. Each additional cabinet can accommodate up to 4 additional channels. This streamlined, compact design means low initial cost, high reliability and low maintenance costs.

### VME Based Controller

The front-end interface and control section of the ESIG-3000 features a VME architecture. The use of a VME chassis with a commercial off-the-shelf 68030 processor board, standard interfaces, cost effective SCSI storage and backup devices, and a commercial real-time operating system offers expansion and flexibility.

A special IG interface board provides a VME interface to the IG, as well as a second SCSI port to the IG. During database paging, data is transferred directly from the disk to the IG channel processors without burdening the VME processor bus.



ESIG-3000 Offers Modular Architecture

### Fully Channelized Architecture

The fully channelized architecture of the ESIG-3000 offers several advantages over other designs. Each channel processor has independent memory, computational units and rendering hardware. Thus, there are no system capacity restrictions; the system capacity grows linearly with the addition of channel processors. This results in independent channel operation for such applications as offset eyepoint, LOD management and sensor effects.

### Parallel, Programmable, Database Processing units.

Efficient database processing is realized in the ESIG-3000 by the use of parallel, programmable processing. To do this, the database management and geometric processing sections utilize very high speed floating-point digital signal processor circuits. These processor units have direct access to large high speed memories in each channel processor which hold the active data base elements. A dual memory and bus structure allows database management and geometric processing functions to be performed independently and without interference, but with full cross communication. The processing units operate in parallel to provide a wide variety of computational operations. Additional units may be added to each channel processor to increase system capacity and add functionality.

Up to 3000 potentially viewable, textured and smooth-shaded polygons can be processed in each channel processor at a 60 hertz update rate. Aggressive database management techniques ensure that all of the 3000 polygons contribute effectively to the scene. Equivalent scenes without effective management can require tens of thousands of polygons to achieve comparable results.

### Parallel Image rendering.

The ESIG-3000 system also features an expandable image rendering section which allows expansion in rendering performance as well as resolution. Additional hardware can be added in a modular fashion in each channel processor to produce up to 1.5 million pixel resolution at a 60 hertz update rate.

### Multiple Viewports from a Single Channel.

The system can also be configured to provide two or more viewports or visual channels from a single channel processor. Multiple display interfaces may be inserted into a single channel processor, and the computational power of a single channel processor may be shared between two or more video outputs.

## Advanced Features

---

### R-Buffer

The ESIG-3000 system utilizes an R-buffer approach to occultation. An R-buffer is an enhanced Z-buffer using true range to scene elements, as opposed to Z-relative depth. Unlike the Z-buffer, the R-buffer does not place limits on the maximum field of view (FOV). The Z-buffer cannot resolve the relative depth between two objects in a direction that is perpendicular to the Z-axis of the display coordinates. The R-buffer of the ESIG-3000 allows continuous field of view wider than 180 degrees, as required in many dome applications.

### The Hybrid R-Buffer

While the R-buffer may be used to determine proper occultation of all scene elements, the ESIG-3000 also retains the rendering advantages afforded by the cellular priority technologies established with the E&S CT-5. This hybrid R-buffer approach, mixing R-buffer occultation for moving models and fixed-priority relationships for stationary scene elements, provides rendering efficiencies unmatched by traditionally Z-buffer architectures.

Ordered priority relationships, based on separating planes and ordered listings, may be specified internal to objects whose geometry does not change dynamically. Representative objects might include a group of buildings and trees; or the wings, engines and stabilizers of an aircraft. For these objects, the polygons are submitted to the rendering hardware in priority order. The hardware then takes advantage of marking as filled, all display areas as they are initially being filled. Future fixed-ordered polygons which are hidden behind these filled areas need not be processed. The ability to reject hidden areas at a high level in the pixel processing hierarchy allows significant time savings.

After taking advantage of these efficiencies, R-buffer sorting can then be used to determine occultation of moving objects with other moving or fixed objects in the scene. For example, an aircraft may taxi into a hanger with the R-buffer determining occultation between the parts of the hanger and the aircraft.

Processing resources saved through this hybrid approach are used to render scenes of higher depth complexity than would be possible otherwise. Thus, the ESIG-3000 hybrid R-buffer architecture is more efficient and powerful than a standard Z-buffer solution.

### Moving Model Management Using the R-Buffer

With the incorporation of an R-buffer, the ESIG-3000 system is equipped to accommodate large numbers of moving models in the scene. The occultation will be correct for models as they move relative to one another, in and around features on the terrain, and move behind and in front of hills and mountains.

Unlike present systems, the linking of specific model types (e.g. an F-16 aircraft, a fuel truck or an HH-60 helicopter) to motion parameters is placed under control of the host computer. The host can specify the addition of different model types, assign multiple instances of model types and reassign motion parameters in real time. The system supports complex chaining of coordinate systems, including eyepoints on chained model members, collision detection relative to articulated parts of moving models, and even the hand-off of a moving object from one moving model to another moving model.

### Photo-Realistic Texture Capability

The ESIG-3000 has powerful texturing capabilities which can be used to provide photo-realism. The system allows the application of up to 4-texture patterns to each polygon. Each of the four maps can be given different scale factors and are antialiased independently. An automatic contrast adjustment takes place among the four patterns, ensuring that scene detail maintains contrast due to the application of multiple maps. These factors are essential to providing continuous emergence of texture detail over the extremely wide viewing ranges typical of most training scenarios.

A wide range of texture types is available, from the exciting new full-color texture to contour texture, with its characteristically sharp, well defined boundaries. Three types of color texture are provided, as well as a new type of texture, called "select texture," which uses one texture map to mix two other texture and color patterns in a controllable and unique manner.

### Non-Linear Image Mapping (NLIM)

ESIG-3000 employs a powerful non-linear image mapping technique which allows accurate correction for display system non-linearities without distracting anomalies such as popping, cracking or scene overload. Screen distortions, lens distortions, projector placement, and projector geometric alignment can be accommodated with accuracies of better than one pixel for most applications.

The image mapping solution takes place early in the computational path, preserving image resolution and quality, and providing for fields of view larger than 180 degrees. The image mapping solution is highly integrated into dedicated processing hardware so that its application does not affect either polygon or pixel capacities.

## **Additional Features**

---

### **Database Compatibility**

The ESIG-3000 system exhibits a high degree of database compatibility with ESIG-100, 200, 500, 600 and 1000 systems. Although the ESIG-3000 offers significant performance improvements over these other systems, databases for those systems can be directly recompiled to operate on the new system, thus protecting customers past investments for progress into the future.

### **High-Fidelity Sensor Simulation**

The ESIG-3000 employs many features which make it the obvious choice for high fidelity sensor simulation as well as out-the-window visual simulation. From the Evans & Sutherland powerful correlated database modeling tools to the highly capable IR post-processor, the ESIG-3000 has addressed all of the difficult issues of sensor simulation.

Database models contain material code information as well as visual color information. Alternate texture maps, processed specifically for sensor effects, can be loaded for the sensor channels. Multiple on-line color tables allow channels to be switched from visual to sensor simulation and provide for various seasonal and diurnal changes. Ten-bit resolution throughout the color video computation paths provide for the wide dynamic range required for infrared, low light level TV and light intensification devices.

In a special monochrome mode for FLIR simulation, intensity computations are maintained to greater than 16 bits of resolution to accommodate large offset and gain adjustments. Slewable fields of view, with image stability down to less than a degree, provide the high magnifications used in many of these devices. Evans & Sutherland is committed to the dynamic world of sensor simulation.

## **Output Video Flexibility**

---

### **Programmable Output Video**

The ESIG-3000 contains a programmable pixel clock generator and timing controller which enables virtually any scan standard to be supported. Synchronization pulses can be supplied as horizontal and vertical pulses, a single composite synchronization, or sync on green. The system contains a full video frame buffer with 10 bits each of red, green, and blue video. The inherent image stability offered by non-interlaced output is now available as an optional feature for this high performance image generation system. Genlock circuitry allows the system to be synchronized to an external video source.

### **Programmable Gamma Correction**

Each video output port from the CIG has gamma correction applied. Separate gamma correction functions can be modified and down-loaded for each output to obtain optimum imagery for sensor simulation and for various display types.

### **Edge Blending and Pixel Packing**

When displaying non-rectangular viewing windows, the CIG can optimize pixel processing to be performed only in the viewing area (known as pixel packing). It can also blank pixel regions outside of the FOV. Edge blending can be performed on the boundary pixels to provide a smooth transition between adjacent projectors. A programmable high-resolution table is used to provide the blending function, and can be tuned to provide proper blending and geometric alignment. An optional post-processing unit is also available to provide an even wider range of edge blending when necessary.

ESIG-3000 PERFORMANCE SUMMARY

PRIMARY PRODUCT EMPHASIS	<ul style="list-style-type: none"><li>• <b>Optimized price/performance for hardware</b></li><li>• <b>General high-performance visual system requirements</b></li><li>• <b>Reduced hardware complexity and footprint for optimum life cycle cost</b></li></ul>
MODES	<ul style="list-style-type: none"><li>• Day/Dusk/Night/NVG (Night Vision Goggles)/FLIR (Forward Looking Infrared)</li></ul>
CHANNELS	<ul style="list-style-type: none"><li>• Up to 8 Channel Processors</li></ul>
VIEWPOINTS	<ul style="list-style-type: none"><li>• Multiple viewpoints available, depending on specific application</li></ul>
VISUAL PRIORITY	<ul style="list-style-type: none"><li>• <b>Range Buffer (R-Buffer)</b><ul style="list-style-type: none"><li>- <b>Provides full occultation freedom for moving objects</b></li></ul></li><li>• Fixed-relationship priority also supported</li><li>• <b>Proper occultation for all FOV, including 180 degrees</b></li></ul>
UPDATE/REFRESH RATE	<ul style="list-style-type: none"><li>• 60 Hz or 50 Hz standard</li><li>• Other rates including higher frequencies available</li></ul>
RESOLUTION	<ul style="list-style-type: none"><li>• <b>Expandable to over 1.5M pixels per channel</b></li></ul>
DISPLAYED SURFACES (60 HZ) <ul style="list-style-type: none"><li>• PER CHANNEL</li><li>• TOTAL FOR SYSTEM</li></ul>	<ul style="list-style-type: none"><li>• <b>Expandable to over 3,000</b></li><li>• <b>Up to 24,000</b></li></ul>
DISPLAYED LIGHTS (60 HZ, 0 POLYGONS) <ul style="list-style-type: none"><li>• PER CHANNEL</li><li>• TOTAL FOR SYSTEM</li></ul>	<ul style="list-style-type: none"><li>• Calligraphic lights optional</li><li>• <b>Up to 7,500; trade 2.5:1 with polygons</b></li><li>• <b>Up to 60,000</b></li></ul>
DISPLAY FORMAT	<ul style="list-style-type: none"><li>• Raster; 2:1 vertical interlace standard</li><li>• Pixels can be packed into non-rectangular raster shapes for optimizing resolution</li><li>• <b>Non-interlace configurations available</b></li></ul>
SCAN STANDARDS	<ul style="list-style-type: none"><li>• Software programmable/switchable</li><li>• Genlock capable</li></ul>
DISPLAY DEVICES	<ul style="list-style-type: none"><li>• Software programmable output to drive a variety of display devices:<ul style="list-style-type: none"><li>- Calligraphic monitors or projectors</li><li>- Head- or eye-slaved displays</li><li>- Direct view CRT monitors, CRT projectors, light valve projectors</li><li>- Helmet mounted displays</li><li>- Display devices with non-rectangular active display areas</li></ul></li></ul>
DISTORTION CORRECTION	<ul style="list-style-type: none"><li>• <b>Non-Linear Image Mapping (NLIM) hardware standard</b><ul style="list-style-type: none"><li>- <b>Wide dynamic range to drive advanced displays</b></li><li>- <b>Compatible with dynamic NLIM option</b></li><li>- <b>Compatible with FOVs greater than 180°</b></li><li>- <b>No capacity or performance compromise</b></li><li>- Dynamic or static linear off-axis correction available</li></ul></li></ul>
COLORS	<ul style="list-style-type: none"><li>• Four on-line 512-entry color tables</li><li>• Additional 1024 material types</li><li>• Two entries per polygon to serve simultaneous visual and sensor channels</li></ul>
TEXTURE	<ul style="list-style-type: none"><li>• Hardware is standard</li><li>• <b>Up to 256 high resolution maps (128x128)</b></li><li>• <b>Programmable map resolution, from 64x64 up to 512x512</b></li><li>• 4 texture maps per polygon</li><li>• <b>Full-color texture</b></li><li>• Texture motion for animation/motion without using dynamic coordinate systems (for clouds, water, smoke, etc.)</li><li>• Contour texture for complex shapes with high edge quality</li><li>• Modulation texture for "wallpaper" texturing</li></ul>

DATABASE MANAGEMENT	<ul style="list-style-type: none"><li>• Multiple LOD on terrain and features</li><li>• Fade LOD blending</li></ul>												
OVERLOAD TECHNIQUES	<ul style="list-style-type: none"><li>• Dynamic level of detail range adjustment, field time extension, frame rate update</li></ul>												
FEATURE INSTANCING	<ul style="list-style-type: none"><li>• Ability to provide instancing of library features</li></ul>												
MOVING OBJECTS	<ul style="list-style-type: none"><li>• <b>Up to 253 addressable moving objects</b></li></ul>												
ANIMATION	<ul style="list-style-type: none"><li>• Up to 256 different representations per animated object, for animation via rapid cycling</li></ul>												
TRANSPORT DELAY	<ul style="list-style-type: none"><li>• 3-1/2 field times standard for ownship (i.e. 60 msec at 60 Hz including display field)</li></ul>												
SIMULATION FUNCTIONS													
<ul style="list-style-type: none"><li>• COLLISION DETECTION</li></ul>	<ul style="list-style-type: none"><li>• Reports interference of point(s) on ownship or other Dynamic Coordinate Systems (DCS) with predefined objects in the database</li></ul>												
<ul style="list-style-type: none"><li>• HEIGHT ABOVE TERRAIN</li></ul>	<ul style="list-style-type: none"><li>• Reports height of host-defined points or DCSs above terrain surface or above database features</li></ul>												
<ul style="list-style-type: none"><li>• LINE-OF-SIGHT RANGING</li></ul>	<ul style="list-style-type: none"><li>• Reports range from viewpoint to specific database features in field of view</li></ul>												
<ul style="list-style-type: none"><li>• INTERVISIBILITY</li></ul>	<ul style="list-style-type: none"><li>• <b>Reports intervisibility between points in database, 360° coverage</b></li></ul>												
LANDING LIGHTS	<ul style="list-style-type: none"><li>• Multiple lobe representations per channel</li><li>• Steerable lobe searchlight</li></ul>												
LIGHT PATTERNS	<table><tr><td>• Flashing</td><td>• Rotating</td><td>• Directional</td><td>• Strobing</td></tr></table>	• Flashing	• Rotating	• Directional	• Strobing								
• Flashing	• Rotating	• Directional	• Strobing										
ATMOSPHERIC EFFECTS	<table><tr><td>• Clouds</td><td>• Fog/haze</td><td>• Ground fog</td><td>• Patchy fog</td></tr><tr><td>• Glare</td><td>• Scud</td><td>• Horizon glow</td><td>• Lightning</td></tr><tr><td>• Thunderstorm cell</td><td>• Wet runway</td><td>• Snow covered runway</td><td></td></tr></table>	• Clouds	• Fog/haze	• Ground fog	• Patchy fog	• Glare	• Scud	• Horizon glow	• Lightning	• Thunderstorm cell	• Wet runway	• Snow covered runway	
• Clouds	• Fog/haze	• Ground fog	• Patchy fog										
• Glare	• Scud	• Horizon glow	• Lightning										
• Thunderstorm cell	• Wet runway	• Snow covered runway											
SURFACE EFFECTS	<table><tr><td>• Flat shading</td><td>• Smooth shading</td></tr><tr><td>• Fixed shading</td><td>• Transparency</td></tr><tr><td>• Self luminous surfaces</td><td></td></tr></table>	• Flat shading	• Smooth shading	• Fixed shading	• Transparency	• Self luminous surfaces							
• Flat shading	• Smooth shading												
• Fixed shading	• Transparency												
• Self luminous surfaces													
SPECIAL EFFECTS	<ul style="list-style-type: none"><li>• <b>Dynamic flares (illuminating the terrain and features)</b></li><li>• Multiple moving targets</li><li>• Weapons effects</li><li>• Fire and smoke</li></ul>												
SENSOR SIMULATION	<ul style="list-style-type: none"><li>• Electro-Optical Sensor Simulation</li><li>• Infrared sensor simulation</li><li>• Enhanced dynamic range of intensity calculations for IR simulation</li></ul>												
LIBRARIES	<table><tr><td>• Scene components</td><td>• Terrain databases</td></tr><tr><td>• Aircraft</td><td>• Ground vehicles</td></tr><tr><td>• Natural features</td><td>• Cultural features</td></tr></table>	• Scene components	• Terrain databases	• Aircraft	• Ground vehicles	• Natural features	• Cultural features						
• Scene components	• Terrain databases												
• Aircraft	• Ground vehicles												
• Natural features	• Cultural features												
GENERAL PURPOSE COMPUTER	<ul style="list-style-type: none"><li>• <b>Internal VME 68K-based</b></li><li>• Ethernet, HSD and other interfaces available</li></ul>												

**Bold type indicates significant new features in the ESIG-3000.**  
Note: Some specifications are dependent on overall system configuration and database design, resulting in tradeoffs to optimize IG performance for a specific application.

EVANS & SUTHERLAND

SIMULATION DIVISION

600 Komas Drive, Salt Lake City, Utah 84108 Telephone: (801) 582-5847 FAX: (801) 582-5848